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Computer-Generated Imagery

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Introduction

Computer-generated imagery or CGI is an area of digital visualization practices that, following its emergence in the late 1960s, quickly came to hold a privileged relationship to film production —affecting in particular animation, special effects, and the big-budget blockbuster. In these areas, digital imaging is consistently pushed to its limits by an ever-advancing state of the art. In a view promoted by the industry through plentiful "making-of" coverage, CGI is strongly identified in the popular imagination with spectacular special effects, demonstrating Hollywood's prowess at realizing fantastic visions. But CGI plays a more significant if quieter role in its so-called invisible effects, which begin with the unnoticeable retouching of filmed "truth" and ripple outward to what some have warned is the destabilization of the cinematic medium itself, replacing the industry at every level—from production to exhibition and distribution—with its digital other. Academic attention to CGI grew slowly alongside its emergence as a powerful if alien force in filmmaking and film culture during the 1980s and 1990s but took off after the crucial year of 1999, when *The Matrix* heralded the fusion of analogue and digital cinema. Along with celebrity, CGI has become a key focus of popular attention on "behind the scenes" information, and an industrial entry point for fledgling filmmakers with access to cheap digital tools. But even as it extends the powers and profits of the film industry, CGI has challenged established practices and definitions, destabilizing film's ontological base, its indexical relationship to reality, the tenets of classical narrative structure, and even the boundaries separating film from other media such as video games and experimental art.

Foundational Works

Although early and classical film theory paid some attention to cinema's uncanny and spectacular elements, it was not until Bazin 1967 (originally 1945) defined the chief strength of film as its power to record and reproduce reality that critical awareness of the medium's opposite tendency—creating "unreality" through manipulation—began to crystallize. While Youngblood 1970, Metz 1977, and Gunning 1990 each lay a piece of the groundwork for discussing the synaesthetic, psychological, and spectatorial functions of specifically cinematic spectacle, Heilig 2001 (originally 1955) and Sutherland 2001 (originally 1965) come at similar questions from the viewpoint of a different medium, the computer, placing emphasis on interactivity, design, and spatial architectures that would later become important aspects of virtual reality and video gaming.

Bazin, André. "The Ontology of the Photographic Image." In *What Is Cinema?* Vol 1. Edited and translated by Hugh Gray, 9–16. Berkeley: University of California Press, 1967.

A cornerstone of realist film theory, this republished 1945 essay situates cinema within a long tradition of arts that share the ideal of freezing or "mummifying" reality. For Bazin, cinema's unique aesthetic properties flow from its automatic reproduction of profilmic reality, promising to reveal our world with new objectivity. Originally published as "Ontologie de l'image photographique," in *Les problèmes de la peinture*, edited by Gaston Diehl (Paris: Confluences, 1945) (accessible online).

Gunning, Tom. "The Cinema of Attractions: Early Films, Its Spectator, and the Avant-Garde." In *Early Cinema: Space, Frame, Narrative*. Edited by Thomas Elsaesser, 56–62. London: British Film Institute, 1990.

A crucial rethinking of film form and reception in its first decade, arguing that early cinema was spectacular rather than narrative, organized around the presentation of startling, theatrical "attractions" rather than the seamless verisimilitude that came to dominate with the rise of classical Hollywood narrative.

Heilig, Morton. "The Cinema of the Future." In *Multimedia: From Wagner to Virtual Reality*. Edited by Randall Packer and Ken Jordan, 219–231. New York: W. W. Norton, 2001.

This republished 1955 essay by a Hollywood cinematographer paints an embryonic picture of virtual reality, extrapolating from then-current exhibition formats of 3D and Cinerama to eventual modes of immersive simulation involving all five senses. Originally published as "El Cine del Futuro: The Cinema of the Future," *Espacios* 23–24 (1955).

Metz, Christian. "*Trucage* and the Film." *Critical Inquiry* 3.4 (Summer 1977): 657–675.

Building on his masterpiece *The Imaginary Signifier* (Bloomington: Indiana University Press, 1982), Metz's short essay examines film "trickery" or *trucage* from a psychoanalytic perspective, emphasizing the spectator's knowing disavowal and providing a taxonomy of types and degrees of photographic manipulation. Includes the famous statement "All of cinema can be considered, in some sense, a special effect." Translated from the French by Françoise Meltzer.

Sutherland, Ivan. "The Ultimate Display." In *Multimedia: From Wagner to Virtual Reality*. Edited by Randall Packer and Ken Jordan, 232–236. New York: W. W. Norton, 2001.

First published in 1965, this essay by an MIT computer-graphics pioneer surveys in both speculative and concrete terms the types of input and output devices needed to create immersive, 3D environments through digital technology. First published in 1965, *Proceedings of IFIP* (International Federation for Information Processing) 65.2: 506–508, 582–583.

Youngblood, Gene. *Expanded Cinema*. New York: E. P. Dutton, 1970.

A visionary, impassioned screed in the spirit of Marshall McLuhan, assessing the entangled evolution of filmmaking, communication technology, and human consciousness. While the focus ranges from television to cybernetics and holography, key chapters examine then-cutting-edge forays into machine-assisted filmmaking and the work of pioneering computer animator John Whitney. Introduction by Buckminster Fuller.

Reference Articles

Given the technical and frequently spectacular nature of CGI, it is not difficult to find information on the design and making of high-tech movies, profiles of individuals and companies important to the industry, and celebrations of particular techniques (see Industrial and Technical Resources). While such texts can be useful aids in navigating the technological complexity of digital image creation, their implicit promotional inflection and sometimes too-tidy ways of narrating the history of CGI, special effects, and cinema are insufficient; it is a good idea to also consult more-inclusive, critical work. Baker 1993 is one possible source, written at an important juncture in CGI's development, around the time of *Terminator 2: Judgment Day* (1991), *Jurassic Park* (1993), and *Forrest Gump* (1994), which brought digital imaging to broad popular consciousness as a new weapon in the arsenal of blockbuster cinema. More than a decade later, Enticknap 2005 meticulously mapped a cinematic landscape transformed by the processes first identified by Baker.

Baker, Robin. "Computer Technology and Special Effects in Contemporary Cinema." In *Future Visions: New Technologies of the Screen*. Edited by Philip Hayward and Tana Wollen, 31–45. London: British Film Institute, 1993.

Proposes a set of categories for understanding the emergent aesthetics of computer-generated imagery, followed by a detailed survey of key moments in CGI's deployment in narrative film throughout the 1970s and 1980s. Dated but informative.

Enticknap, Leo. "New Moving Image Technologies." In *Moving Image Technology: From Zoetrope to Digital.* By Leo Enticknap, 202–231. London: Wallflower, 2005.

A useful, admirably clear-eyed survey of digital technology's effect not just on film imagery but sound, editing, exhibition, and archiving, as well as the related media of film, television, and the Internet. Skeptical toward the wooliness of conceptualizations of the digital.

Anthologies

Although no anthologies to date have focused specifically on CGI in relation to cinema, Sobchack 2000 and Strauven 2007 historicize and theorize digital visual effects. Balcerzak and Sperb 2009 concentrates on changes in viewer affect and cinematic phenomenology in the transition to a digital era, while Shaw and Weibel 2003 explores the notion of a postphotographic cinema through a richly illustrated selection of digitally based arguments and artworks.

Balcerzak, Scott, and Jason Sperb, eds. *Cinephilia in the Age of Digital Reproduction: Film, Pleasure and Digital Culture*. Vol. 1. London: Wallflower, 2009.

This rambunctious anthology deploys a long-debated term in film studies, cinephilia, as a way of getting at contemporary digital imaging and the passionate spectatorial and theoretical engagements it provokes. Its essays, mostly by promising new scholars, seek to bring historical roots, along with transmedia scope, to a transforming cinema.

Shaw, Jeffrey, and Peter Weibel, eds. *Future Cinema: The Cinematic Imaginary after Film*. Electronic Culture—History, Theory, Practice. Cambridge, MA: MIT Press, 2003.

A sizeable and profusely illustrated compendium on seemingly every conceivable aspect of digital image culture, collecting well over 100 contributions from historical and current media theorists, philosophers, inventors, and artists. Originally published to accompany a 2002–2003 art exhibit at the German ZKM Institute for Visual Media, it is beautifully laid out, though in too artful a format to serve conveniently as a textbook.

Sobchack, Vivian, ed. *Meta-Morphing: Visual Transformation and the Culture of Quick-Change*. Minneapolis: University of Minnesota Press, 2000.

Concentrating on a single special-effects concept widely popular in the 1990s, the morph, this energetic and approachable set of essays frames it through the lenses of

history, narrative-technical practice, and human subjectivity. Collects many of the most important voices writing on special effects today, including Sobchack, Klein, Ndalianis, and Bukatman.

Strauven, Wanda, ed. *The Cinema of Attractions Reloaded*. Amsterdam: Amsterdam University Press, 2007.

A dense and authoritative volume compiled for the 20th anniversary of Tom Gunning's canonical essay (Gunning 1990; cited under Foundational Works) examining the "attraction" as a historical, aesthetic, and theoretical practice with considerable staying power. Exemplary in its polished merging of voices from all points on the disciplinary map of film and media studies, including animation. Suited to graduate study.

Journals

It is a promising sign that articles on CGI-related topics are now turning up in major film journals such as *Film Quarterly* and *Screen*, usually treating digital imaging as an element in larger theoretical analyses. For specific accounts of CGI as a technical and aesthetic process, *Cinefex* remains the single best resource, though readers may find *American Cinematographer* more accessible for its contextualization of new media in relation to the established practices of the film trade. Among scholarly journals, *Animation: An Interdisciplinary Journal* treats CGI as an equal player in contemporary animation, expanding the scope to include digital-media siblings such as video games.

American Cinematographer. 1919–.

Published monthly by the American Society of Cinematographers (ASC) and a reliable, regular source of background information on important or unusual film projects. Provides substantial behind-the-scenes coverage of film and television production, interviews with industry professionals, and discussions of new and evolving technologies of film visualization.

Animation: An Interdisciplinary Journal. 2006–.

Published three times a year by SAGE, this theoretically inclined journal of animation studies frequently touches on issues of digital imaging, in particular those arising at the border between traditional and computer animation, such as protocols of storytelling, representation, and performance. Published since 2006.

Cinefex. 1980–.

Now in its fourth decade of publication, *Cinefex* has never varied from its successful formula: in-depth case studies of state-of-the-art films, anatomizing the production of their special effects in loving, accurate detail. Handsomely produced, illustrated with plentiful color photographs. Nonacademic; a quarterly aimed at professionals and technically oriented fans.

Special and Visual Effects

Attention to CGI in film and media studies has largely centered on special effects—the creation of subtle or spectacular screen illusion by deceptive means. Both an industrial category and a spectatorial one, special effects cultivate a dual sense of wonder toward the potentialities of narrative cinema, helping to tell (and sell) its most ambitious stories while also providing opportunities beyond the immediate viewing situation to go "behind the scenes" to see how the tricks were done—a second, technophilic order of spectatorial fascination. While special effects and the science fiction/fantasy/horror genres in which they play a privileged role were the subject of critical scrutiny before the coming of the computer (see The Analogue Era), the adoption of CGI as a default visual-effects and production tool in the 2000s dramatically expanded the pool of scholarship. Case studies of particular special effects, reading their tropes and formal behaviors as one would a genre, can be found in Rehak 2007 and Whissel 2006. Widening the scope, other writers provide cultural histories of CGI effects, with Pierson 2002 examining their popular reception; Ndalianis 2004, their linkages to transmedia blockbusters; and Klein 2004, their ancestry in politics and architecture. A third set of works debate the estranging effects of CGI on the medium, with Cubitt 2004 highlighting their essential uncanniness, whereas McClean 2007 and Tryon 2009 see a more harmonious narrative integration. Finally, North 2008 synthesizes many of these points of view, arguing that CGI effects represent the latest evolution of long-standing patterns of narrative and spectacle in film.

Cubitt, Sean. *The Cinema Effect.* Cambridge, MA: MIT Press, 2004.

Retells the history of cinema from the perspective of its digital present, treating special effects as an emblem for the medium's essentially uncanny and dreamlike nature. Rich in its interdisciplinary borrowings.

Klein, Norman. *The Vatican to Vegas: A History of Special Effects.* New York: New Press, 2004.

Working with an elastic definition of special effects that encompasses architecture and political spectacle, Klein leapfrogs through 450 years of history to explore the ways in which "scripted spaces" have always functioned in dialogue with regimes of social power and the body—the collective and individual subject—of their time. Impressionistic and even somewhat novelistic.

McClean, Shilo T. *Digital Storytelling: The Narrative Power of Visual Effects in Film*. Cambridge, MA: MIT Press, 2007.

McClean, herself a storyboarding and special-effects consultant, employs her familiarity with the industry to argue against the often-heard charge that the excessive spectacle of the CGI era has eroded traditional narrative practices. Plentiful examples and case studies are scrutinized to show how digital visual effects, like any storytelling tool, have good and bad uses.

Ndalianis, Angela. *Neobaroque Aesthetics and Contemporary Entertainment.* Media in Transition. Cambridge, MA: MIT Press, 2004.

Tracing special-effects prehistory further than most, Ndalianis finds in the Baroque movement of the 17th century a frame for discussing the next three centuries of visual entertainment technologies, from portraiture and video games to comic books and theme-park attractions, particularly in their use of complexity to appeal to our senses and imaginations.

North, Dan. *Performing Illusions: Cinema, Special Effects and the Virtual Actor*. London: Wallflower, 2008.

North lays out a theory of special effects as artifice designed to be noticed, tracing this history back to the magic shows of Georges Méliès's time and forward through stop-motion animation and science fiction films of the 1950s. The endpoint of his discussion is the synthespian or virtual performer, whom North shows to be the product of cultural codes as much as of computer technology.

Pierson, Michele. *Special Effects: Still in Search of Wonder*. Film and Culture. New York: Columbia University Press, 2002.

A work of cultural studies as well as film theory, Pierson's book examines communities of film-technology connoisseurs across the decades, and the role of behind-the-scenes information in reproducing popular understandings of special effects. Elegantly conceived and useful in its demonstration that the discourses around CGI shape not just its reception but its evolution.

Rehak, Bob. "The Migration of Forms: Bullet Time as Microgenre." *Film Criticism* 32.1 (2007): 26–48.

A study of the unique properties of a single, briefly celebrated special effect, "bullet time," and by extension the cultural routes by which special effects travel through copying, citation, and parody.

Tryon, Chuck. "The Screen Is Alive: Digital Effects and Internet Culture in the 1990s Cyberthriller." In *Reinventing Cinema: Movies in the Age of Media Convergence*. By Chuck Tryon, 38–58. New Brunswick, NJ: Rutgers University Press, 2009.

Part of a larger study of the reshaping of film and film culture by new media, this chapter examines a generic cycle of films at the end of the millennium that used their CGI-centered storylines as a way of speculating about the coming digital future.

Whissel, Kristen. "Tales of Upward Mobility: The New Verticality and Digital Special Effects." *Film Quarterly* 59.4 (Summer 2006): 23–33.

Selected by Braudy and Cohen to conclude the seventh edition of the *Film Theory & Criticism* reader (New York: Oxford, 2009), this essay describes an emerging aesthetic of digital effects, placing it against a backdrop of real and cinematically portrayed historical change.

The Analogue Era

Within film studies, the first academics to write about CGI did so using conceptual tools developed for an earlier time—the predigital or "analogue" period of film production whose hundred-year existence we can name as such only in its passing—and often within the context of special effects and the science fiction (SF) films that put them to their most visible work. The miniature models, matte paintings, and prosthetic makeup of that era constituted a rich semiological bed for scholars influenced by 1970s "Grand Theory." Kuhn 1990 most clearly shows the stamp of Lacan, Althusser, Kristeva, and Mulvey, while Sobchack 1998, first published in 1980, contributes a genre study of SF in the tradition of *Sixguns and Society*. A more materialist approach to special effects can be found in La Valley 1985 and Bukatman 2003, both interested less in spectatorial experience or genre history than in the types of displays put on by spectacular films: the show-stopping performance of technology itself. Turnock 2009 also casts an eye toward industrial performance, with its study of a pivotal period in which analogue effects readied themselves for the coming of digitalization.

Bukatman, Scott. *Matters of Gravity: Special Effects and Supermen in the 20th Century*. Durham, NC: Duke University Press, 2003.

Showcases a decade of eloquent and adventurous theorizing, often from the vantage point of art and history, on industries of visualization and fantasy in mass culture, with two foundational essays on special effects, “The Artificial Infinite” (pp. 81–110) and “The Ultimate Trip” (pp. 111–131), anchoring other investigations into comic books, Walt Disney, and Hollywood musicals.

Kuhn, Annette, ed. *Alien Zone: Cultural Theory and Contemporary Science Fiction Cinema*. London: Verso, 1990.

A breakthrough volume that gathers together diverse essays on science fiction film published in scattershot fashion during the 1980s, highlighting shared concerns in their studies of fantastic representation. Feminist theory animates the book’s most resonant sections, on ideology and the body, but other essays focus on special effects as phenomena in themselves—very much Gunning’s tamed attractions (Gunning 1990; cited under Foundational Works)—including Neale’s important essay (pp. 160–168) on knowledge, judgment, and belief in special-effects spectatorship.

La Valley, Albert J. “Traditions of Trickery: The Role of Special Effects in the Science Fiction Film.” In *Shadows of the Magic Lamp: Fantasy and Science Fiction in Film*. Edited by George Slusser and Eric S. Rabkin, 141–158. Carbondale: Southern Illinois University Press, 1985.

An expanded version of a paper written for a 1982 conference, this essay is included both because it was one of the first to pay equal attention to special effects’ narrative and industrial nature, and because despite its historical reach—all the way back to Méliès and *Metropolis*—it stems from a particularly active period in special-effects design, including the first experiments with CGI, in the late 1970s and early 1980s.

Sobchack, Vivian. *Screening Space: The American Science Fiction Film.* 2d ed. New Brunswick, NJ: Rutgers University Press, 1998.

First published in 1980 and reprinted in 1987, Sobchack’s book was for many years the preeminent structural and stylistic study of science fiction film, breaking the genre into its characteristic themes, preoccupations, and (important for special effects) iconography. A model of formal genre analysis.

Turnock, Julie. “Before Industrial Light and Magic: The Independent Hollywood Special Effects Business, 1968–75.” *New Review of Film and Television Studies* 7.2 (2009): 133–156.

Closely examines the special-effects industry in the years before *Star Wars*, arguing that that film’s arrival—and subsequent elevation of Industrial Light and Magic’s (ILM’s) photorealist approach—led to a dominant style of special effects that has both absorbed and neglected more-unconventional, experimental uses.

Spectacle and the Blockbuster

For these writers, special effects evolved into CGI as part of a larger strategy to keep pace with the demands of a thriving blockbuster film industry—one that in its endless expansion and pursuit of new markets and ways to repurpose itself has become difficult to distinguish from the media web of television, video games, and the Internet. Hall and Neale 2010 surveys the economic and technological backbone of the blockbuster industry, while King 2000 and Bordwell 2006 concentrate on the permutations of film form and narration specific to high-concept, franchise-building, CGI-laden cinema.

Bordwell, David. “A Certain Amount of Plot: Tentpoles, Locomotives, Blockbusters, Megapictures, and the Action Movie.” In *The Way Hollywood Tells It: Story and Style in Modern Movies*. By David Bordwell, 104–114. Berkeley: University of California Press, 2006.

Although not focused on CGI, Bordwell’s chapter examines the charges typically made against blockbuster cinema in areas such as overreliance on spectacle, debunking many of them through reference to classical Hollywood principles of story construction. As with all of the author’s work, lucid, logical, and difficult to dispute.

Hall, Sheldon, and Steve Neale. “Ancillary Markets, Globalization, and Digital Technology, 1986–2009.” In *Epics, Spectacles, and Blockbusters*. By Sheldon Hall, and Steve Neale, 235–259. Hollywood History. Detroit: Wayne State University Press, 2010.

A detailed and dispassionate history of the blockbuster industry’s most recent phase of development, in which digital technologies have extended film’s global reach and commercial afterlife while generating new forms of ticket-selling spectacle.

King, Geoff. *Spectacular Narratives: Hollywood in the Age of the Blockbuster*. London: I. B. Tauris, 2000.

Seeks a middle ground between the sides of the spectacle/narrative debate, examining special effects and genres such as action and war films to argue for a more generous understanding of how image and story intertwine.

Performance

As the goal of CGI imaging has narrowed from epic vistas to the scale of the human body, digital actors or synthespians have become more common, a challenge academics have met by drawing on theories of acting and performance. Balcerzak 2009 and Bode 2010 focus on the ways in which the underlying "aura" of a human performer is transferred to screen bodies, while Purse 2007 frames digital characters through the types of punishment they dish out, and receive, in action films.

Balcerzak, Scott. "Andy Serkis as Actor, Body and Gorilla: Motion Capture and the Presence of Performance." In *Cinephilia in the Age of Digital Reproduction: Film, Pleasure and Digital Culture*. Vol. 1. Edited by Scott Balcerzak and Jason Sperb, 195–213. London: Wallflower, 2009.

This essay explores the way that motion capture, the process of translating a performer's movement and expression into a digital character, problematizes theories of acting and screen presence.

Bode, Lisa. "No Longer Themselves? Framing Digitally Enabled Posthumous 'Performance.'" *Cinema Journal* 49.4 (2010): 46–70.

Examining the special case of dead actors whose performances are reconstituted by digital means, this essay brings together theories of expressive performance and visual-effects technology.

Purse, Lisa. "Digital Heroes in Contemporary Hollywood: Exertion, Identification and the Virtual Action Body." *Film Criticism* 32.1 (2007): 5–25.

Considers the use of synthespians in blockbuster action cinema, where the indestructibility of the digital body both reinforces and complicates the types of viewer fascination and identification this genre attracts.

Animation

One of the most fertile homes for CGI is in animated shorts and feature films, exemplified by the output of Pixar from *Toy Story* (1995) onward. Beck 2004 and Telotte 2010 walk us through animation's lengthy and colorful history with an eye on its eventual digital destination, while Buchan 2006 blends CGI and animation to generate a third productive term, the animated "world." Sobchack 2006 provides a penetrating critique of digital animation's aims and limits in regard to synthespian performance.

Beck, Jerry, ed. *Animation Art: From Pencil to Pixel, the History of Cartoon, Anime and CGI.* New York: Harper Design International, 2004.

An oversized, comprehensive encyclopedia of a century of animation in film, television, and digital media, beautifully illustrated. Impressive in its historical and global reach. A good reference book for teaching preparation.

Buchan, Suzanne, ed. *Animated "Worlds."* Eastleigh, UK: John Libbey, 2006.

Buchan, editor of *Animation: An Interdisciplinary Journal* (see Journals), edited this collection of transdisciplinary essays that weave together literary, cinematic, and game-studies perspectives on the fictional worlds called into existence by the arts.

Sobchack, Vivian. "Final Fantasies: Computer Graphic Animation and the (Dis)Illusion of Life." In *Animated "Worlds."* Edited by Suzanne Buchan, 171–182. Eastleigh, UK: John Libbey, 2006.

A densely theoretical analysis of *Final Fantasy: The Spirits Within* (CD; New York: Sony Classics, 2001), which claimed to feature the first cast of photorealistic synthespians, and a meditation on the "uncanny valley" that divides life from its simulacrum. Originally a conference paper.

Telotte, J. P. *Animating Space: From Mickey to Wall-E*. Lexington: University of Kentucky Press, 2010.

Mapping animation practice in terms of a shift from modernist to postmodernist spatial aesthetics, Telotte connects pioneers in animation such as Walt Disney and Ub Iwerks to contemporary practitioners of the art such as Robert Zemeckis and Pixar Studios.

Film in Transition

For some, CGI is merely the visible manifestation of a deeper shift in cinema's identity, in which the medium's principal claim to uniqueness—its power to record and reproduce the world before the camera—is undermined by the power of digital imaging to rewrite that reality, and the mechanics of camera, film, sound, and projection are being rapidly replaced by electronic alternatives. The works in this section examine key aspects of this period of profound change, from film's last hold on indexicality to the emergence of a truly digital cinema. Friedberg 2000 provides a recent historical framework for this transformation, while Rodowick 2007 marshals a formidable array of theory to reflect on what might be lost in the coming era. Andrew 2010 resituates debates in classical film theory against the backdrop of contemporary cinema. Finally, Tryon 2009 considers the effect of media convergence and digital technologies on film exhibition and reception culture.

Andrew, Dudley. *What Cinema Is!* Bazin's Quest and Its Charge. Blackwell Manifestos. Malden, MA: Wiley-Blackwell, 2010.

Andrew constructs a history of cinema ranging from Bazin and the classical era to contemporary debates about auteurism and adaptation.

Friedberg, Anne. "The End of Cinema: Multimedia and Technological Change." In *Reinventing Film Studies*. Edited by Christine Gledhill and Linda Williams, 438–452. London: Arnold, 2000.

Comments on the process of media evolution (with its consequent extinctions and adaptations) through an analysis of film's convergence with television and, later, digital systems of storage and display.

Rodowick, D. N. *The Virtual Life of Film*. Cambridge, MA: Harvard University Press, 2007.

Poses the question of what happens to cinema when its ontological base—film—is replaced by a digital counterpart, taking a cautious and critical approach to the philosophical implications of old versus new media at a key moment of industrial and phenomenological transition.

Tryon, Chuck. *Reinventing Cinema: Movies in the Age of Media Convergence*. New Brunswick, NJ: Rutgers University Press, 2009.

A thorough consideration of the transformations in exhibition and reception that film is undergoing in the digital era, including consideration of DVD extras and blog culture.

Indexicality

In classical semiotics, indexical signs are those produced through direct physical encounter with their referent—fingerprints, bullet holes, the smoke rising from a fire. From the start, cinema's relationship to reality seemed based on a similar principle, its images formed by traces of light reflected off objects and recorded in changes to the chemical substrate of film. An analogue process in the most literal sense, this relationship has been complicated by the digitalization of filmmaking, which allows everything from unnoticeable tinkering to the creation of whole worlds and life forms that never held material existence before the camera. Mitchell 1992 and Prince 1999 sound the clearest alarm bells around the erosion of indexicality and subsequent untrustworthiness of photographic images. Gunning 2010 and Rosen 2001 answer this criticism by carefully parsing the often-hyperbolic claims about digital technology's lack of precedent. Finally, Ng 2007 provides an account of digital-optical hybridity at both the technological and philosophical levels.

Gunning, Tom. "Moving Away from the Index: Cinema and the Impression of Reality." In *The Film Theory Reader: Debates and Arguments*. Edited by Marc Furstenau, 255–269. Routledge Global Security Studies. London: Routledge, 2010.

A concise overview of recent debates about digital media's alleged lack of indexicality. Originally published in 2007.

Mitchell, William J. *The Reconfigured Eye: Visual Truth in the Post-Photographic Era*. Cambridge, MA: MIT Press, 1992.

Mitchell's book captures a period of profound skepticism toward digital imaging in the early 1990s, when the plasticity of realistic computer graphics seemed to threaten the very tenets of representation. Although it resonates with current concerns, the inescapable datedness of its examples makes it more interesting as an evolutionary stage in the critical discourses around CGI.

Ng, Jenna. "Virtual Cinematography and the Digital Real: (Dis)placing the Moving Image Between Reality and Simulacra." In *The State of the Real: Aesthetics in the Digital Age*. Edited by Damian Sutton, Susan Brind, and Ray McKenzie, 172–180. London: I. B. Tauris, 2007.

A short but incisive discussion of how digital technologies force a rethinking of not just cinematographic, but photographic principles.

Prince, Stephen. "True Lies: Perceptual Realism, Digital Images, and Film Theory." In *Film Quarterly: Forty Years—A Selection*. Edited by Brian Henderson and Ann Martin, 392–407. Berkeley: University of California Press, 1999.

Originally published in 1996, this essay seeks to locate a middle ground between indexicality and illusion by pointing out the reliance of CGI on perceptual cues—such as dimensionality and surface texture—that embed even the most fantastic imagery in recognizable reality.

Rosen, Philip. "Old and New: Image, Indexicality, and Historicity in the Digital Utopia." In *Change Mummified: Cinema, Historicity, Theory*. By Philip Rosen, 301–349. Minneapolis: University of Minnesota Press, 2001.

In this crucial riposte to the assertion that digital images constitute a new, postphotographic regime, Rosen draws on Bazin to argue that new media are animated by many of the same reality-capturing tendencies as traditional optical recording.

Digital Cinema

The works in this section share characteristics with those in New Media but differ in that they insist on cinema as a foundation for understanding recent developments in CGI. In some way, all take up questions of film's potential obsolescence and its self-reinvention to adapt to changing times. Keane 2007 and Rombes 2009 provide the most-thorough explorations of digital cinema from formal and technological perspectives, while Mulvey 2006 supplies a rather melancholy, theoretical take on the same processes. Aldred 2006 and Crockett 2009 isolate new phenomenologies inherent to CGI imagery and camerawork. Finally, one might read Belton 2002 and Manovich 2010 against each other in a point-counterpoint on whether digital cinema marks a radical break with the past.

Aldred, Jessica. "All Aboard *The Polar Express*: A 'Playful' Change of Address in the Computer-Generated Blockbuster." *Animation: An Interdisciplinary Journal* 1.2 (2006): 153–172.

A case study of the groundbreaking, CG-animated, performance-captured film *The Polar Express* (2004), this essay examines how Gunning's early-cinema attraction has been reconfigured as the center of an emerging aesthetics of spectacle and game-like immersion in contemporary blockbusters.

Belton, John. "Digital Cinema: A False Revolution." *October* 1.100 (2002): 98–114.

Arguing that the digital colonization of cinema occurred not all at once but in distinct phases over many years, Belton suggests in this tart essay that the revolutionary nature of digital cinema has been overstated by an industry all too happy to encourage big-budget spending and the development of new home-entertainment markets.

Crockett, Tobey. "The '*Camera* As Camera': How CGI Changes the World as We Know It." In *Cinephilia in the Age of Digital Reproduction: Film, Pleasure and Digital Culture*. Vol. 1. Edited by Scott Balcerzak and Jason Sperb, 117–139. London: Wallflower, 2009.

Boldly proposes the emergence of "a new posthuman author" at work in CGI-heavy blockbusters, where virtual cinematography promises to dissolve Cartesian space and give rise to new forms of technologized subjectivity.

Keane, Stephen. *CineTech: Film, Convergence, and New Media.* New York: Palgrave Macmillan, 2007.

A handy summary of current theory and debates about media convergence, this slim and crisply written book examines film production and aesthetics during a period of profound change. Good as a primary text for undergraduates or as background reading for graduate students.

Manovich, Lev. "Digital Cinema and the History of a Moving Image." In *The Film Theory Reader: Debates and Arguments*. Edited by Marc Furstenau, 245–259. London: Routledge, 2010.

Condensing a decade's worth of insights of one of the field's earliest and most prophetic theorists of new media, this essay succinctly lays out an archeology of the immersive, interactive image, and in so doing reveals cinema as one stage in a larger trajectory of human art, seeking to bring painterly control to captured reality.

Mulvey, Laura. *Death 24x a Second: Stillness and the Moving Image*. London: Reaktion Books, 2006.

An elegant meditation on how digital technologies transform the experience of older films, including new forms of pleasure to be gleaned from the still-framed, delayed, and replayed image. Case studies of films by Hitchcock, Rossellini, and Kiarostami (pp. 85–143).

Rombes, Nicholas. *Cinema in the Digital Age.* London: Wallflower, 2009.

Turning away from spectacular visions and giant blockbusters, this book focuses on small, independent films from outside the United States to map changes in cinema's characteristic themes and aesthetics. Most notable for its suggestion that new forms of visual imperfection are coming into existence as an almost-symptomatic compensation for the digital's impression of flawlessness.

New Media

The "C" (computer) in CGI ties this field inescapably to digital technology and the new aesthetics and practices arising from it—a heterogeneous field that includes entertainment, information, and art; broadcasting and narrowcasting; and simulation and interactivity. The works in this section address the intersection of digital technologies with cinema, video, and live performance, as well as their role in blurring distinctions and encouraging the flow and mutation of forms, aesthetics, and narrative among media platforms. For inclusive maps of the new-media landscape, Bolter and Grusin 2000 and Manovich 2001 are indispensable. Willis 2005 concentrates on transformations of cinema, while Darley 2000 and Wood 2007 investigate a range of immersive entertainment experiences. Sutton, et al. 2007 ranges outside even these broad categories, probing the roots of today's digital-virtual episteme.

Bolter, Jay David, and Richard Grusin. *Remediation: Understanding New Media*. Cambridge, MA: MIT Press, 2000.

Though published more than a decade ago, this influential updating of McLuhan remains a readable and provocative textbook for new-media studies. Its central insight: every new medium "remediates" characteristics of the prior ones, a principle amply demonstrated by computer graphics' colonization of industrial niches such as architectural design, television news and advertising, and cinematic special effects and animation.

Darley, Andrew. *Visual Digital Culture: Surface Play and Spectacle in New Media Genres*. Sussex Studies in Culture and Communication. London: Routledge, 2000.

Under his concept of "visual digital culture," Darley aligns videogames, CGI films, and theme-park rides as an overall trend toward simulationist entertainment, tracing the history of their emergence and the theoretical implications of their immersive aesthetics.

Manovich, Lev. *The Language of New Media*. Cambridge, MA: MIT Press, 2001.

A cornerstone of new-media theory at the dawn of the 21st century, Manovich's book was the first to authoritatively stake out a distinct vocabulary for talking about digital imaging and processes, calling attention to its algorithmic, combinatorial nature and the connection among graphic simulation, technologies of storage and communication, and emerging narrative forms.

Sutton, Damian, Susan Brind, and Ray McKenzie, eds. *The State of the Real: Aesthetics in the Digital Age*. London: I. B. Tauris, 2007.

With roots in a 2003 conference at the Glasgow School of Art, this collection examines the destabilization of the concept of the "real" in the face of virtual reality, new media, and other practices of science and visualization such as biotechnology. Truly interdisciplinary, bringing together film scholars, artists, and philosophers, while drawing on a deep history of modernity's theoreticians.

Willis, Sharon. *New Digital Cinema: Reinventing the Moving Image*. Short Cuts 25. London: Wallflower, 2005.

Embracing the idea that digital technology has transformed cinema at every level, this slim volume in the Short Cuts series explores not just changes in live-action filmmaking but design, experimental art, music video, and animation.

Wood, Aylish. *Digital Encounters*. London: Routledge, 2007.

In this theorization of screens and interfaces, Wood makes a powerful argument for the reshaping of our mediascape by emerging technologies. Her examples range widely, from art installations to video games.

Virtual Reality and Video Games

Computer science and video game studies are distinct fields with only occasional connection to film and media studies; one of their few areas of overlap is CGI, taken here to refer to the creation of digital images in the service of interactive, explorable spaces. The same algorithmic processes that generate computer graphics drive the operation of physics and artificial-intelligence engines, which sometimes then feed back into cinematic visual effects, as in the clashing armies of the *Lord of the Rings* trilogy (2001–2003). Benedikt 1991 remains a seminal anthology of virtual reality's baby steps. Mactavish 2002 and Ward 2002, from the same collection on film-digital crossovers from a gaming perspective, examine spectacle and animation in video games. Surman 2006 finds in the concept of the game world a format linking design, software, and fiction.

Benedikt, Michael, ed. *Cyberspace: First Steps*. Cambridge, MA: MIT Press, 1991.

Reprinted several times following its original publication in 1991, this early collection of essays brings together computer scientists, cultural theorists, and artists whose work from the 1960s through the 1980s engaged with simulated digital spaces. Topics include online social communities and virtual worlds, the mediation of identity by avatars, and new fields of design and architecture.

Mactavish, Andrew. "Technological Pleasure: The Performance and Narrative of Technology in *Half-Life* and Other High-Tech Computer Games." In *ScreenPlay: Cinema/Videogames/Interfaces*. Edited by Geoff King and Tanya Krzywinska, 33–49. London: Wallflower, 2002.

In the vein of film scholarship that asserts a basic structural distinction between spectacle and narrative, this essay investigates the spectacular elements of video games, arguing that graphically intensive game experiences center on the self-conscious demonstration—and glorification—of the computer's advanced display abilities.

Surman, David. "Style, Consistency and Plausibility in the *Fable* Gameworld." In *Animated "Worlds."* Edited by Suzanne Buchan, David Surman, and Paul Ward,151–170. Eastleigh, UK: John Libbey Publishing, 2006.

This essay uses the example of *Fable*, a 2004 role-playing game, to put forth a model of diegesis (or story world) specific to video gaming. Surman's analysis touches on questions of internal consistency, visual design, and player interaction.

Ward, Paul. "Videogames as Remediated Animation." In *ScreenPlay: Cinema/Videogames/Interfaces*. Edited by Geoff King and Tanya Krzywinska, 122–135. London: Wallflower, 2002.

Building on Bolter and Grusin's model of remediation (see New Media), this boundary-crossing essay suggests that video games borrow and adopt many traits of animation. An important exploration of the intimate relationship between cinematic and digital media.

Industrial and Technical Resources

While not classified as traditional scholarship, the works listed here are useful for grasping the intricacies of a highly technical process (indeed, a process that has come to be synonymous with the prowess and potential of technological imaging). They are also helpful as instances of what John T. Caldwell has called "production culture"—the discourses by which industries narrate and assign meanings to their activities. Vaz and Duignan 1996, Rubin 2006, and Price 2008 trace the development of CGI in two leaders of the field, Pixar Studios and Industrial Light and Magic (ILM), while Netzley 2001 provides a helpful checklist of key technical concepts, as well as a detailed filmography. The most comprehensive picture of special-effects history and practice comes from Rickitt 2000.

Netzley, Patricia D. *Encyclopedia of Movie Special Effects*. New York: Checkmark, 2001.

A no-nonsense, A–Z approach to important films, artists, and techniques in the world of filmed illusion. Includes appendices on Academy Award nominees and winners for special effects, special-effects magazines, and special-effects houses.

Price, David A. *The Pixar Touch: The Making of a Company.* New York: Alfred A. Knopf, 2008.

Paying equal attention to technological innovation and the economics of the media-entertainment business, Price profiles the rise of Pixar Studios, which spun off from ILM in the 1980s and has since come to dominate the CGI-animated film market.

Rickitt, Richard. *Special Effects: The History and Technique*. New York: Billboard, 2000.

A thorough, clearly conceived, and clearly written guide to special effects from the inception of cinema to its digital present. Rich with screen captures, behind-the-scenes photographs, and graphics that illuminate even the most elaborate and abstruse techniques.

Rubin, Michael. *Droidmaker: George Lucas and the Digital Revolution*. Gainesville, FL: Triad, 2006.

Details the development of digital imaging and production tools at ILM in the late 1970s and early 1980s. Dense with technical detail and insider narratives.

Vaz, Mark Cotta, and Patricia Rose Duignan. *Industrial Light & Magic: Into the Digital Realm*. New York: Ballantine, 1996.

This volume charts the special-effects house's pioneering experiments with computer-assisted compositing, animation, and theme-park ride design, culminating in the production of the first virtual actors. Covers some of the same ground as does Rubin 2006, but in a more obviously promotional fashion.

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